Pump

The invention relates to a pump with at least two pump pistons moving on a common circular path.

Pumps, so-called vacuum pumps, are already known in various configurations. For example, continuously rotating radial compressors are known, but also piston-compressor pumps performing reciprocating movements or oscillating movements.

By contrast, the invention is concerned with a novel pump with at least one pump piston moving on a circular path and a pump housing, the pump piston, optionally coupled in a rigid manner to one or more further pump pistons, moving in an oscillating manner about an axis of rotation on a path of movement correspondingly having two reversal positions, and furthermore a medium being discharged via an outlet valve and, in the course of movement from one reversal position into the other reversal position, an inlet valve being opened, after which, in the course of a pressure buildup, the medium is discharged on a pressure side of the pump piston then obtained and taken in on a suction side of the pump piston then obtained.

With such a pump, higher output values can be achieved, for instance in comparison with radial compressors. In this case, the pump is of a comparatively simple construction.

The subject matters of the further claims are explained below with reference to the subject matter of Claim 1, but may also be of importance in their independent formulation.

In one configuration, it is provided that the inlet valve is run over in the movement from one reversal position into the other reversal position.

The pump pistons move in a pump chamber. The pump chamber is formed radially on the inside by an inner wall preferably formed rotationally fixed with respect to the pump piston. If a number of pump pistons are provided, it is preferably also the connecting wall between two or more pump pistons. The housing wall bounding the pump chamber radially on the outside is suitably formed in a fixed manner. However, as explained in more detail further below, it may also be movable. The inlet valve may be formed in the pump chamber floor and/or in the pump chamber ceiling and/or in the housing outer wall and/or in the housing dividing wall.

The pump chamber is bounded in the direction of movement of a pump piston - on both sides - by a fixed housing dividing wall. In the case of two pump pistons, the housing dividing walls divide the two pump chambers. This housing dividing wall makes it possible for the pressure to build up - to the desired degree - when the pump piston moves into the reversal position. The outlet valve is preferably formed as a check valve. The outlet valve may be formed in the housing dividing wall and/or in the pump chamber floor and/or in the pump chamber ceiling and/or in the housing outer wall.

The pump may be driven for example by an electric motor. However, it may also be driven by some other motor. As still to be explained below, it is recommendable specifically to perform the power transmission by means of a crankshaft.

The motor may also be an electric motor directly producing the reciprocating movement. In this case, the electric motor may, more specifically, be a customary universal motor. It may, however, also be a so-called reluctance motor. A stepping motor is suitable for example for directly producing the reciprocating movement. In addition, it is also possible for instance to provide an electric or electromagnetic spring/mass system as the drive. The masses have to be balanced.

Important here is the disposition of the axes of the drive and the pumps, for instance if two pumps with one, central, drive are connected to each other. Although the reversal positions of the pistons of the two pumps are in-phase, in the intermediate positions different angular positions are obtained, and a phase deviation that is dependent on the position of the center points. This can be minimized by deliberate height settings between the drive axis and the pump axis.

When the drive power is transmitted to the pump by means of a crankshaft, it is also recommendable to drive two or more such pumps simultaneously. The crankshaft makes it possible for the motor, that is in particular the electric motor, to perform a continuous movement. The limited-angle reciprocating movement of the pump or the pump pistons is produced by means of connecting rods acting on the crankshaft in a way known per se, comparable with a petrol engine or diesel engine in the motor vehicle sector. The two pumps of this type, driven with preference by means of the same crankshaft, then suitably move in opposite directions.

Special attention is paid to the sealing of the pump pistons in the pump housing. It is first provided, for

example in the circumferentially outer region, but also the inner circumferential region, for instance in interaction with the housing dividing wall that is fixed with respect thereto, that the effective gap is formed with such a length that the length of the gap alone produces suitable sealing. This at least with a sufficiently small gap size, preferably in the range of hundredths of a millimeter, at least not significantly exceeding a range of tenths of a millimeter. More preferred are gap sizes in a range of a few hundredths of a millimeter.

Furthermore, however, separate sealing lips may be used there or on one or more of the surfaces interacting in a sealing manner and/or a coating that abrasively works itself in over the course of operation of the pump is applied at least to one of the surface areas which interact with one another.

The reciprocating movement or oscillating movement of the pistons is performed in such a way that there is preferably not quite any contact with the housing dividing wall. In the reversal position, the respective pump piston stops a few tenths of a mm before the housing dividing wall, or a few percent, or preferably a few tenths of a percent, with respect to the range of rotational angles passed through by the pump pistons in the movement from one reversal position into the other.

More specifically, the housing dividing wall may be formed in such a way that the distance from the associated piston area is constant over a radial in the range of circumferential angles of greatest approximation. However, it may also be chosen such that (straight surface area) a wedge-shaped, (radially)

outwardly widening gap is obtained between the associated areas in the position referred to.

The range of rotational angles of a piston is preferably about 90°. It may, however, also extend beyond this, for instance up to +/-30°, while including corresponding intermediate stages such as 95°, 100°, 105°, 110° etc., as well as angular ranges lying in between. The same applies with respect to values below 90°. In this way, concordance can be brought about between the respective charging volume and the piston size.

The pump pistons themselves preferably consist of a lightweight material such as aluminum. With greater preference, they comprise extruded sections (although this is not dependent on aluminum as the material). To this extent, the construction is designed in such a way that the great masses are pushed radially outward as far as possible with respect to the axis of rotation of the pump pistons. Altogether, the moved masses should be as small as possible, because of the moments of inertia occurring, for which reason a lightweight material, such as aluminum, is indeed recommendable for the moved masses.

When formed as extruded sections, the pump pistons have corresponding cavities. These may be closed at the top and bottom by a cover.

The height of the pump pistons or their extent in the axial direction of the common axis of rotation preferably corresponds approximately to a diameter from the axis of rotation to the outer circumferential wall of a pump piston. It is the aim here to minimize the gaps.

An inlet valve may be formed as a simple permanent opening. For instance in the form of a bore or else in the form of a groove. In addition, it may also be formed as a check valve (for example a ball valve).

In the case of the pump with two pump pistons, four outlet valves and two inlet valves are respectively provided. However, four inlet valves may also be provided, if for instance the other two are in each case turned off.

As a further alternative, the inlet valve and the outlet valve may be associated with the same end region of the path of movement, that is to say specifically a respective reversal position. The inlet valve and the outlet valve may in this case be provided adjacent each other. In this respect, it proves to be advantageous if the inlet valve and the outlet valve are disposed in the same housing dividing wall.

The inlet valve and/or the outlet valve may in this case be formed from a punched or bent sheet-metal part, with a closure plate associated with a valve opening and an adjoining bending-out portion. In this respect, a steel sheet-metal part may be provided, in particular one formed from spring steel. With further preference, the inlet valve and/or the outlet valve has here closure plates and bending-out portions merging with each other in a coplanar manner. These are accordingly preferably disposed without any offset in relation to each other with respect to a plane. Furthermore, an inlet valve and/or an outlet valve has a mounting foot, which is for example mounted in a clamping manner, in particular mounted in a clamping manner in the region of the housing dividing wall. With preference, this mounting foot also merges at least partially with the bending-out portion in a coplanar manner.

For the sealing closure of the inlet valve and/or the outlet valve, the closure plate preferably rests on a sealing support, which is mounted in a clamping manner between the valve and the associated housing part. It may also be adhesively attached for instance. In the case of the mounting in a clamping manner, this is preferably achieved by means of a clamping part or a pressure part. The support may be formed by a part made of plastic, for example an elastomer.

In particular in the case of the configuration of the valves in the form of punched or bent sheet-metal parts, which are substantially made up of a mounting foot, a bending-out portion and a closure plate, the longitudinal extent of the inlet valve and/or of the outlet valve runs in the direction of the axis of rotation of the pump pistons. It is therefore also possible for a number of outlet valves to be disposed next to one another in the direction of the axis of rotation. It is also conceivable here for a number of inlet valves to be correspondingly disposed next to one another in alignment with the axis of rotation.

Partial positioning of a spring-loaded inlet valve with respect to the outlet valve in the housing dividing wall proves to be advantageous with respect to a reduction of the power consumption during intake, i.e. renewed filling of the pressure chamber. The difference in pressure is reduced as a result. The valve - both the inlet valve and the outlet valve - is formed as a lubricant-free spring valve, more specifically with preference as a tongue valve with a seal made of an elastomer.

It is further preferred for the valves to be formed in a valve strip that can easily be exchanged or

converted. Including in such a way that the outer edge disposition of the inlet valve can be switched to the outer edge disposition of the outlet valve or vice versa by simply turning the valve strip round. This is of significance for the possibly desired interconnection of a number of pumps in series or parallel. According to the situation, the required valve can then be disposed (by turning the valve strip) in such a way that long gas flow ducts are not required. To this extent, the valve strip is formed in mirror image with respect to a longitudinal axis. Inlet valves and outlet valves in each case lie opposite one another with respect to a center longitudinal axis of the valve strip.

The valve tongues of the tongue valves are symmetrically formed. Spring steel would be suitable as a material, or else Viton for example. The fact that the valves are planar allows a very minimized dead space to be accomplished with respect to a reversal position of a piston. The inlet valves are flush with the surface of the valve strip. With respect to the outlet valves, a thin wall thickness is accomplished in the valve strip and/or a U-shaped part may be additionally formed on the pump piston to avoid the dead space in front of the valve element.

The pump piston may have associated with the outlet valve an opening projection, for the triggering of the outlet valve. If a number of outlet valves are disposed next to one another, a corresponding number of opening projections are provided on the pump piston portion. These raised surface elements on the pump piston interact with the outlet valves, in particular with the spring valves, in the reversal position and correspondingly lead to a mechanical opening of an outlet valve.

It may also be provided that a pump has three, four or more pump pistons, of which at least two move on a common circular path. If different circular parts are provided, on which for example two pump pistons move in each case, these different circular paths are preferably realized in different pump housings. Each pump housing may have here two pump pistons which can be moved in an oscillating manner and the pump chambers of which in the respective pump housing are decoupled from one another by the housing dividing walls.

For the four pistons then obtained in the case of the example referred to above, a common drive is preferably provided, the drive being disposed in a third housing, a drive housing, which is preferably separate from the pump housings, of which there are then two. With further preference, this is then a drive housing with which the two pump housings are associated adjacently on both sides.

The housings - both the drive housing and the pump housings - may be formed as extruded parts. However, they may also be, for example, cast parts. A (first) association and definition of the housings in relation to one another can be achieved by joining them together by means of corresponding longitudinal grooves and longitudinal projections (in the direction of the axes of rotation of the pump pistons), which in the case of extruded parts can be provided at the same time in a simple way. However, these longitudinal grooves and associated projections are generally only to be regarded as assembly aids. In addition, a screwed union and/or an adhesive bond or some other further connection between the housings is appropriate.

In particular if housings are formed as extruded sections, the transfer channel can be integrated into the housing in a simple way. This is so because it can at the same time be incorporated in the housing as a cavity which extends in the direction of the axes of rotation of the pump pistons and is subsequently closed on one or both sides by corresponding covers.

For the sealing of the pump chamber, the pump piston and/or the pump housing may be flocked in the surface area of an associated movement gap. This flocking forms a running-in coating, which during the first operating cycles is removed by abrasion to produce a minimal gap. The flocks produce an advantageous labyrinthine effect. In this respect, it is of course also possible for other coatings that abrasively work themselves in (which do not necessarily also have to have the advantage of a labyrinthine seal) to be alternatively applied.

In the pump piston consisting of aluminum, for example, a shrink-fitted steel shaft may be provided for forming the physical axis of rotation.

The geometry of the pump chamber is preferably square, that is to say the free path of the pump pistons between the reversal positions corresponds approximately to the extent of the pump chamber in the direction of the axis of rotation. The aim is to minimize the gap lengths. This is preferably in accordance with the formula that the sum of twice the gap length and twice the difference between the outer radius and the inner radius of the pump chamber is minimized. It is also quite possible to realize pump chamber geometries in which the free path of the pump pistons between the reversal positions is less than the extent of the pump chamber in the direction of the axis

of rotation and in which the free path of the pump pistons is made greater than the extent of the pump chamber in the direction of the axis of rotation.

The invention is further explained below on the basis of the drawing, which merely represents a number of a exemplary embodiments or configurational variants and in which:

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| Figure 1 | shows a schematic top view of the pumps in a first embodiment; |
| Figure 2 | shows a schematic perspective view of two pump pistons connected to each other; |
| Figure 3 | shows a schematic view of two pumps driven at the same time by means of a drive; |
| Figure 3a | shows a schematic representation of a crankshaft flange-mounted on the drive; |
| Figures 4 to 6 | show details with respect to the sealing and valve actuation of the pump pistons with respect to the housing; |
| Figure 7 | shows a possibility for the configuration of the housing dividing wall with outlet valves; |
| Figure 8 | shows a partial representation for an alternative embodiment; |

Figure 9 shows a perspective representation of a housing dividing wall with inlet and outlet valves disposed in it;

Figure 10 shows an exploded perspective representation of the housing dividing wall according to Figure 9;

Figure 11 shows a longitudinal section through a pump housing with a view of a further alternative embodiment of housing dividing walls having outlet valves;

Figure 12 shows a perspective detailed representation of the region of a pump chamber with outlet valves disposed in a housing dividing wall;

Figure 13 shows a representation corresponding to Figure 12, but for an alternative embodiment, in which the rotary piston has opening projections associated with the outlet valves;

Figure 14 shows a detailed representation according to the representation in Figure 4, but for an alternative embodiment with regard to the gap sealing;

Figure 15 shows a representation corresponding to Figure 5, but for the sealing configuration corresponding to Figure 14;

Figure 16 shows the pump in a cross section;

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| Figure 17 | shows the pump according to Figure 16 in a view from the rear; |
| Figure 18 | shows a drive housing with separate pump housings disposed on both sides in a perspective representation; |
| Figures 19 to 21 | show partial views of a valve strip with further embodiments of the inlet/outlet valves; |
| Figures 22 to 24 | show sectional views with respect to Figures 19 to 21; |
| Figure 25 | shows a representation according to Figure 17, but with separately formed pump housings within an overall housing; |
| Figure 26 | shows a further view of the subject matter according to Figure 25, with a crank drive acting on the pump housings. |

Shown and described in first instance with reference to Figure 1 is a pump 1 with two pump pistons 2, 3, which are connected to each other via a common central region 4, which in the case of the exemplary embodiment has a basically circular cross-section. In the central region 4, there is also at the center the axis of rotation 5, about which the pump pistons 2, 3 rotate back and forth in an oscillating manner.

During operation, pump pistons 2, 3 are moved out of the position represented in Figure 1 (first reversal position) clockwise until they reach the second reversal position, then running over the inlet valve 9

in each case. After that, a pressure builds up between the pump piston and the housing webs 6, 7, until the preset counterpressure of the outlet valve 8 is reached (or, as described further below, a forced opening takes place). The pump pistons are then in one reversal position. Starting from there, they are actively moved back, in a direction opposite to that of the first movement, and the process is repeated in this reversed direction of rotation.

The pump pistons covering an angular range α of about 60° in the exemplary embodiment correspondingly move in each case over an angular range of 120°. In the region of 180°, two housing dividing walls 6, 7 are formed lying opposite in the pump housing 18 (only schematically represented). In the case of the exemplary embodiment according to Figure 1, an outlet valve 8 is formed upstream of the housing dividing wall 6 and 7, respectively, in the direction of rotation of a pump piston 2, 3. Approximately in the 90° region of the 180° pump chamber in which a pump piston 2 or 3 moves, an inlet valve 9 is formed.

In the case of an embodiment that is an alternative in this respect, the pump pistons are formed over an angular range of about 90°, so that they also move in each case over an angular range of 90°. Sealing advantages are obtained by the greater sealing lengths. Furthermore, there is the advantage that the inlet valve is not open too long and the gas is not initially pushed out again partly (on the return path).

In addition, angular extents of over 90° are also possible with respect to the piston. For example, 110°, 120° or 130° or interim ranges of degrees with respect thereto. It is then possible to dispense with the compression on the rear side. The inlet valve is

then suitably disposed near the pump piston at the beginning of compression.

While the outlet valves 8 are check valves, an outlet valve 9 is formed as a simple opening.

In Figure 2, a double piston is perspectively represented on its own. A height h of a piston 2 or 3 may correspond to a radius r from the axis of rotation 5 to a piston outer wall 10. Furthermore, a diameter D of the central region 4 preferably corresponds approximately to one third of the overall diameter d of the two pump pistons 2 and 3, formed together with the central region 4 as a unit.

In Figure 3, a drive of two pumps 1 driven together by means of an electric motor 11 is schematically represented. Flange-mounted on the electric motor 11 is a crankshaft 12, which is schematically indicated in Figure 3a and by means of which the pump pistons 2, 3 are driven in opposite directions by means of connecting rods 13. The crankshaft 12 may have a balancing weight or a flywheel mass 14.

The disposition represented is also advantageous to the extent that, while retaining a horizontal position of the shafts, a disposition in a space-saving way is possible in such a manner that the overall unit can stand on just one pump as a base area, that is to say the motor and the further pump then extend above in the manner of a tower, as mentioned with horizontal shafts. This can be advantageously implemented by the housing being formed at the same time in a rectangular way, in the sense that it offers at least two standing areas. One standing area which corresponds to the disposition in Figure 3 and a further standing area for a disposition as described above.

Figures 4 to 6 show details of the gap seals required for a high-performance pump.

In Figure 4, the gap sealing radially outside on the pump piston 3 is schematically represented. As an alternative to the sealing already presented in the introductory part of the description, the pump piston 3 may have as a result of the gap size as such sealing lips 15, which are firmly connected to the pump piston 3 and lie against an inner wall 16 of the pump housing. They may be, for example, lips made of plastic, for instance of PVC, PP or PE.

The same is also possible radially on the inside. Also with respect to the sealing of the housing dividing wall/connecting wall of the pump pistons. In Figure 5, sealing between the housing web 7 and the central region 4 is schematically represented. In this case, a sealing lip 17 is firmly connected to the housing web 6 and interacts in a sealing manner with the inner wall of the pump housing created by the central region 4 and formed rotationally fixed with respect to the pump pistons 2, 3.

In Figure 7, the housing web 6 is represented in an alternative embodiment in a cross-section. In each of the two housing webs 6, 7, one, two or more outlet valves 8 are formed. The outlet valves 8 comprise valve plates 19, 20, which in the case of the exemplary embodiment are connected to one another in a cross-sectionally U-shaped manner and lie under spring biasing against the bores 21, 22. Respectively disposed between the bores 21, 22 and the valve plates 19, 20 are seals 23, 24, which respectively have matching openings corresponding to the bores 21, 22.

As an alternative to opening of the outlet valves by means of the positive pressure produced, it is also possible, in particular when the outlet valves are disposed in the housing webs as represented in Figure 7, for forced opening of the outlet valves to be envisaged, as illustrated in Figure 6. By means of an opening part which is firmly connected to each pump piston and then pushes the valve plates in each case into the open position. This is advantageous in particular with regard to control times to be achieved.

In this connection, but also independently of it, it may also be provided that the associated side walls of the pump pistons 2, 3 just make contact with the respective walls of a housing web 6, 7 in the reversal position. Here it is also advantageous to provide a soft, compliant coating, as accomplished for example by a foam rubber part, on the housing web and/or the associated wall of a pump piston 2, 3.

Figure 8 schematically shows an alternative disposition of outlet valves 8 and inlet valves 9. Here, these are both disposed in the region of a housing dividing wall 6, dividing the two pump chambers 25 from each other. The diametrically opposed housing dividing wall 7 is formed identically to the housing dividing wall 6 that is represented.

As can be gathered in particular from the detailed representation in Figure 9, the housing dividing wall 6 is initially formed as a hollow part with an alignment extending parallel to the axis of rotation 5 of the pump pistons 2 and 3. The cavity formed is interrupted approximately at the center by a transverse wall 26. On both sides of this transverse wall 26, the outlet valves 8 and the inlet valves 9 are formed, the walls

of the housing dividing wall 6 that are facing the pump chambers 25 initially being provided with bores 21, 22.

An inlet valve 9 and an outlet valve 8 are respectively associated with each side of the housing dividing wall 6 that is provided with a bore 21 and 22, respectively, a valve firstly having, irrespective of its function, a closure plate 27, which is adjoined by a bending-out portion 28. The closure plate 27 and the bending-out portion 28 are formed as one part, these merging with each other in a coplanar manner and being formed from a punched or bent sheet-metal part, in particular from a spring steel part. The bending-out portions 28 extend approximately in the longitudinal extent of the housing dividing wall 6, that is to say parallel to the axis of rotation 5.

At the end, that is to say facing away from the valve plate 27, the bending-out portion 28 forms a mounting foot 29. The spring part of the inlet valve 9 that is formed by the valve plate 27, the bending-out portion 28 and the mounting foot 29 is shaped in outline like a key. It may, however, also be shaped as a continuous, straight tongue.

The spring part 30 of the outlet valve 8 has at the end of the bending-out portion 28 two oppositely disposed mounting feet 29, whereby the latter and the bending-out portion 28 are disposed in relation to one another in a T-shaped outline.

Provided between the spring part 30 and the associated wall of the housing dividing wall 6 is a membrane-like support 31, which in the case of the inlet valve 9 is adapted in outline to the outline of the associated spring part 30, cf. in particular Figure 10. Here, too, a stem-like portion 32 is provided, at one end of

which a mounting foot 33 aligned approximately at right angles to it is disposed and the other end of which carries a sealing portion 34, which in the specific exemplary embodiment is in the form of a circular ring and which has an outside diameter which is adapted to the outside diameter of the closure plate 27 and has an inside diameter which is adapted to the diameter of the associated bore 22 in the housing dividing wall 6.

The support 31 of the outlet valve 8 is formed in an oblong manner in outline, with an integrated sealing portion 34 associated with the valve plate 27 of the spring part 30, the through-opening of which likewise corresponds to the diameter of the associated bore 21 in the housing dividing wall 7.

Two inlet valves 9 and outlet valves 8 are provided for each housing dividing wall 6 and 7, each directed to the pump chambers 25 sealed with respect to one another by the housing dividing walls 6, 7. The valves accordingly lie opposite one another in pairs.

The outlet valves 8, or the spring parts 30 and supports 31 forming the outlet valves 8, are disposed on the inside of the housing with respect to the housing dividing wall 6, a support 31 respectively being mounted in a clamping manner between the spring part 30 and the associated housing part. A pressure part 35 is provided for this purpose. This is positioned in the region of the spaced-apart mounting feet 29 of the two spring parts 30 in the hollow chamber-like housing dividing wall. Formed as a result is a bearing on the foot side for the outlet valves 8 formed as spring valves. An adhesive bond may also be provided as an alternative to the mounting in a clamping manner, but if appropriate also in addition to it.

The supports 31 and spring parts 30 of the inlet valves 9 lie in contour-adapted depressions 36 of the outer walls of the housing dividing wall 6 and 7, respectively, that are facing the pump chambers 25, the supports 31 in each case being mounted in a clamping manner between the spring part 30 and the associated housing wall by means of a clamping part 37. This clamping part 37 reaches over the housing dividing wall 6 or 7 in the region of a depression on the top side. In the clamping position, the two legs of the cross-sectionally C-shaped clamping part 37 engage over the mounting feet 33 and 29 of the support 31 and spring part 30, whereby an end mounting of the tongue valves is also achieved here.

Disposing the outlet valves and the inlet valves in the housing dividing wall brings about an advantageously small dead space, and with it better compression.

The valve control preferably takes place pressure-dependently. Therefore, starting from one reversal position, a negative pressure is produced by the pump piston 2 or 3 moving away from the housing dividing wall 6 or 7, respectively, with the effect, possibly after exceeding a preselected threshold value, of opening the inlet valves 9. In the case of a medium-compressing movement of the pump piston 2 or 3, in the direction of the housing dividing wall 6 or 7, a pressure increase is achieved, causing the opening of the outlet valves 8.

The spring parts 30 of the outlet valves 8 are biased in the direction of the associated pump chambers 25, accordingly open inward in the direction of the hollow chamber of the housing dividing wall 6 or 7 when the pressure exceeds the threshold. The spring parts 30 of

the inlet valves 9, on the other hand, are biased in the direction of the associated hollow chamber in the housing dividing wall 6 or 7 and open by bending out in the direction of the pump chambers 25 when a predetermined lower pressure value is exceeded.

As can be further gathered from the sectional representation in Figure 11, it is also possible for a number of outlet valves 8 provided next to one another to be provided in the housing dividing walls 6 and 7. Here, for example, three outlet valves 8 are provided for each housing dividing wall 6 and 7. These outlet valves 8 are formed in a way similar to the outlet valves 8 previously described, accordingly have tongue-valve-like spring parts 30. These spring parts 30 of all three outlet valves 8 of a housing dividing wall 6 or 7 are formed in one piece, the respective mounting feet 29 opening out in a common base 38.

In this exemplary embodiment, the respective inlet valves 9 of each pump chamber 25 are formed as a permanent opening 39, so in the shape of a bore in the bottom region of the pump chamber 25 (cf. in this respect Figure 12). The inlet valve 9 formed in this way is run over during the movement from the one reversal position into the other reversal position.

Furthermore, the representation in Figure 13 shows an alternative embodiment, in which the pump piston 2 or 3 has, associated with the outlet valves 8 disposed next to one another in the housing dividing wall 6, 7, in each case an opening projection 40, for the triggering of the outlet valves 8 by actuation in the one reversal position. By means of these opening projections 40, the closure plates 37 of the outlet valves 8 are mechanically urged into their valve opening position.

Figures 14 and 15 show further details of the gap sealing between the pump pistons 2, 3 and the pump housing. For instance, the pump piston 2 or 3 is provided radially on the outside in the region of the movement gap with a flocking 41, which serves as a running-in layer, which is abrasively removed in the first operating cycles to produce a minimal gap. The same is also possible radially on the inside. For instance, Figure 15 schematically shows a seal with a flocking 41 between the housing web 7 and the central region 4. In addition, such flocking is also provided at the end faces of the pump piston 2, 3, which is not specifically represented. The flocking is only a preferred coating to achieve the desired sealing effect. Other coatings are also possible.

In Figure 16, a cross-section through the pump housing G is represented. This is produced as an extruder part, for example from aluminum, and centrally has a portion for receiving the electric motor 11. Provided on both sides of the electric motor 11 are pump chambers with two pump pistons 2, 3 in each case, which respectively move on a common circular path. Each pump piston 2, 3 is associated with a pump chamber 25, which are separated from one another by diametrically opposed housing dividing walls 6, 7, in which outlet valves 8 are at the same time disposed. The inlet valves 9 are formed at the end faces of the pump chambers 25.

Figure 17 shows a rear view of the pump 1. It can be gathered that the centrally disposed electric motor 11 is used for driving the two pairs of pump pistons disposed to either side of it by means of a crank drive. For this purpose, rotatably mounted extension arms 43 are provided on the electric motor 11 or on its driven shaft 42 and can be used in each case for

driving a connecting rod 13, to drive the pairs of piston pumps in opposite directions.

As an alternative, which is not specifically represented, a stepping motor drive of each pair of pump pistons is also possible here. A further alternative is an electromechanical oscillator.

Finally, the perspective in Figure 18 shows a further embodiment of the pump housing G, which is formed in three parts. Therefore, a drive housing 44 and two pump housings 18 are provided, formed in each case for receiving a pair of pump pistons. These housings are formed as extruded parts, with further preference from aluminum.

The drive housing 44 is appropriately formed for receiving the electric motor 11.

The two pump housings 18 are identically formed such that they can be exchanged for each other and can be disposed symmetrically with respect to the drive housing 44. Correspondingly, the two pump housings 18 may be formed from one and the same extruded section.

The fixing of the two pump housings on the drive housing 44 takes place by means of extruded longitudinal grooves 45 and corresponding, cross-sectionally adapted projections 46. Additionally provided with preference is a pinned connection, screwed union or adhesive bond (in each case alternatively or in combination).

The chosen configuration, in particular of the pump housings 18, makes it possible in the simplest way to achieve different lengths of the pump chambers 25 - with respect to an axis of rotation of the pump

pistons-, whereby the geometry of the pump chambers 25 can be preset, again in the simplest form, in an adaptable manner to different requirements. Preferred here is a pump chamber geometry that is as square as possible, in which the diameter of the pump pistons corresponds approximately to the extent of the pump chamber 25 in the direction of the axis of rotation 5.

Accessory parts such as suction or pressure connection pieces may also be provided at the front and/or rear - considered in the direction of the axes of rotation. Such an accessory may also be integrated here within the form created, for instance in the sense that it is fitted into the intermediate spaces between the motor housing and the drive housing produced in the manner of interstices in the case of the embodiment represented.

The pumps may also have housings that are separate in themselves, with which they are then pushed into the overall housing represented.

With respect to the choice of material, it is provided that the pump piston and the pump housing consist of the same material. If different materials are envisaged, it is provided that the pump piston consists of a material with a lower coefficient of expansion than the material of the pump housing.

Further embodiments of the inlet/outlet valves are represented with respect to Figures 19 to 24.

Formed in the case of the embodiment of Figure 19 is an outlet valve which merely comprises a valve flap 47, which is disposed on the inside of a housing web 6, and the opening - a special opening here - in the housing web 6 or 7. It is important that a multiplicity of individual openings 48 are formed in the region of the

outlet, so that webs serving for supporting the valve flap 47 remain between them. Said valve flap may therefore be made very soft, without unduly forcing its way into the outlet opening under negative pressure.

In principle, the same formation is also possible for an inlet valve. It may be recommendable here to form a recess in which the valve flap lies in the outer wall, in order in this way to maintain a transition that is as planar as possible in the outer wall, between the valve flap and the outer surface.

The cross-sectional representation corresponding to Figure 19 is shown in Figure 22. Here it can be gathered that the one valve flap 47 is in the outlet position, while the other valve flap 47 is lying against the inner wall in a sealing manner.

In the case of the embodiment of Figure 20, a ball valve is realized. It is important to this extent, also with respect to the embodiment of Figure 21, that the outlet valve and inlet valve are formed as a combined valve. The inlet position of the inlet valve is immediately coupled with the sealing position of the outlet valve, and vice versa. A (numeral) active element, here the closure ball 53, is both the active element for the inlet valve and the active element for the outlet valve.

Specifically provided in the case of the embodiment of Figure 20 is a cage 49, which has apertures 50 with regard to a gas supply line - not specifically represented - and a gas discharge line. The cage 49 has, associated with the housing web 6 or 7, a peripheral sealing flange 51, 52. This may also be suitably covered with a sealing material, such as for instance a rubber or elastomer, on the inside, the ball

side. The cage 49 may also consist integrally of such a material. Captured in the cage 49 is a closure ball 53. Depending on the pressure to which it is subjected, this moves into its corresponding sealing position. The cage extends between the housing webs 6, 7, connecting them transversely.

It is evident from the valves described here that only a very small difference in pressure is required for the activation or displacement. They operate without biasing, or virtually without biasing. This is also against the background that the pumps or compressors described here are preferably operated with a small pressure difference. At least whenever a volumetric flow is the primary concern. The pressure difference may be in the range of one or a few tenths of a bar.

With respect to Figures 21 and 24, a valve corresponding to the embodiment of Figure 22 is once again represented, operating at the same time as an outlet valve and inlet valve. It specifically comprises two valve plates 54, 55, which are coupled to each other, preferably in a rigid manner, by means of a connection 56, in the case of the exemplary embodiment in the form of a bar. The connection 56 extends once again transversely in relation to the housing webs 6, 7. Inside the valve strip, or at least between the housing webs 6 and 7, the connection 6 is suspended by means of a spring part 56. It can as a result be aligned with a central position, which corresponds to an opening both of the inlet valve and of the outlet valve. It can by this means also be drawn into a closure position of the inlet valve or outlet valve.

As an alternative or in addition, a merely tubular guidance may also be provided. This in particular if, as a departure from the embodiment actually

represented, one of the valve plates 54 or 55 comes to lie against the inside of a housing wall 6 or 7 in the sealing position.

Represented in Figures 25 and 26 is a pump in which the pump pistons run not only in a separate housing, designated here as the first housing 57, which for its part is then also accommodated in the outer housing 58, but in which the housing 57 is also in each case rotatably accommodated in the housing 58 and, by means of the crank drive represented in Figure 26, is preferably moved by the same drive that drives the pump pistons, oppositely in the case of a pump piston movement. The absolute movement of a pump piston from the one reversal position into the other reversal position can for example be halved as a result (with the same output).

In the case of this embodiment, the housing 58 may also be configured in the same way in a multipart form, as described with reference to Figure 18.

All disclosed features are (in themselves) pertinent to the invention. The disclosure content of the associated/attached priority documents (copy of the prior patent application) is also hereby incorporated in full in the disclosure of the application, including for the purpose of incorporating features of these documents in claims of the present application.